Microcontroller Internet Connectivity

Dr. Svetlana Avramov-Zamurovic
and
Dr. Carl Wick
United States Naval Academy
Annapolis, Maryland

Presentation Overview

- Introduction
- Potential Applications
- USNA - NIST collaboration
- Hardware Solution
- Software Implementation
- System Demonstration
- Conclusions

Introduction

- Need cost-effective, compact hardware that can connect to the Internet
- Low-cost microcontrollers have sufficient power for network applications
- Microcontrollers are widely available and well suited for embedded applications
- Connectivity is appearing in silicon

Potential Applications

- Vending machine status and restocking
- Home automation and security
- Environmental monitoring
- Micro kiosks for Personal Digital Assistants
- Low-cost Internet appliances
- Affordable Internet adapters for existing equipment
- Distributed process control via Internet
- “Minimal” smart spaces

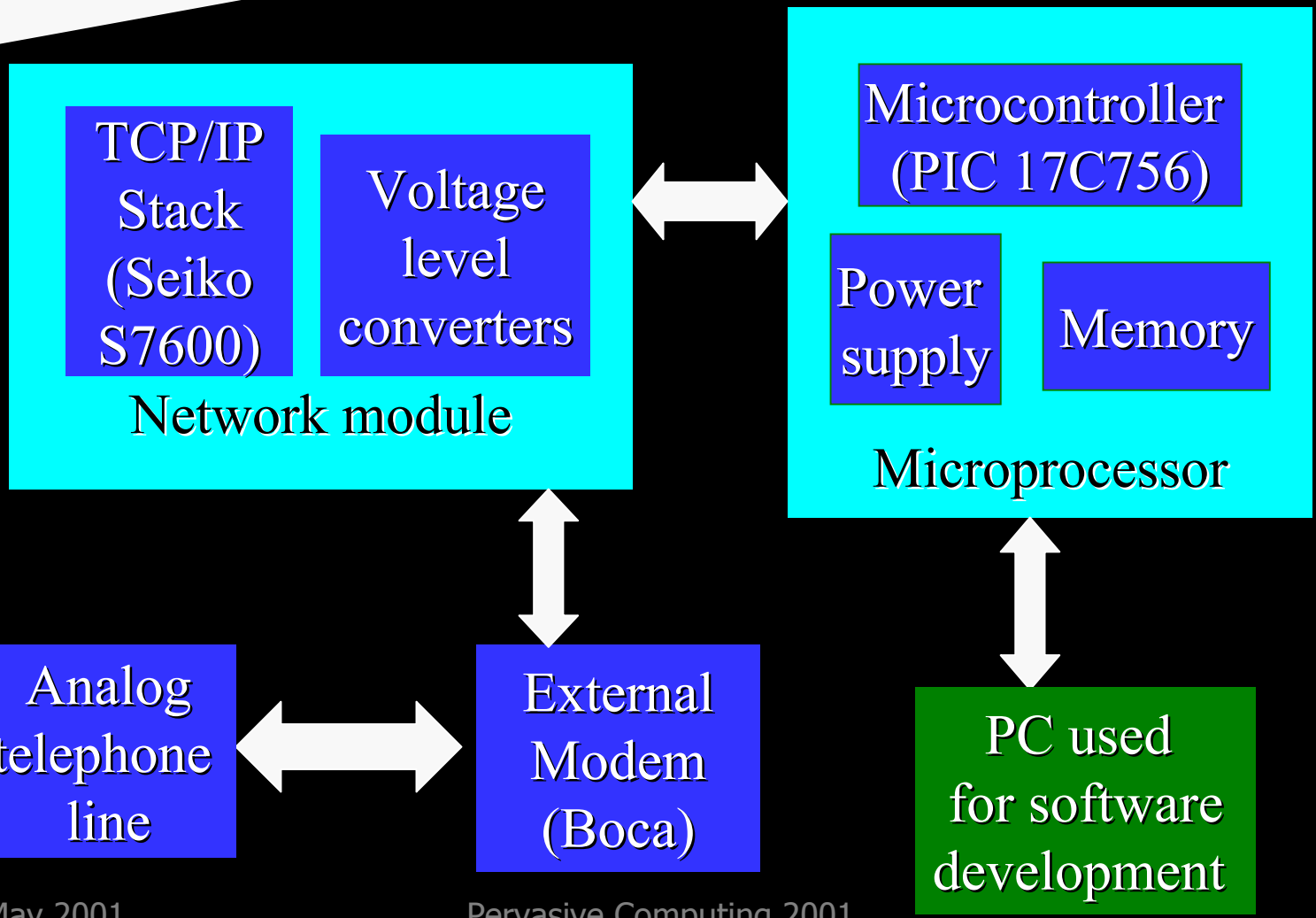
USNA - NIST collaboration

- Information Technology Laboratory at NIST: Alden Dima
  Weapons and Systems Department at USNA: Svetlana Avramov-Zamurovic and Carl Wick
- Goal: To explore use of 8-bit microcontrollers to achieve network connectivity
- Result: Two microcontroller systems were built that use a modem to connect to the Internet

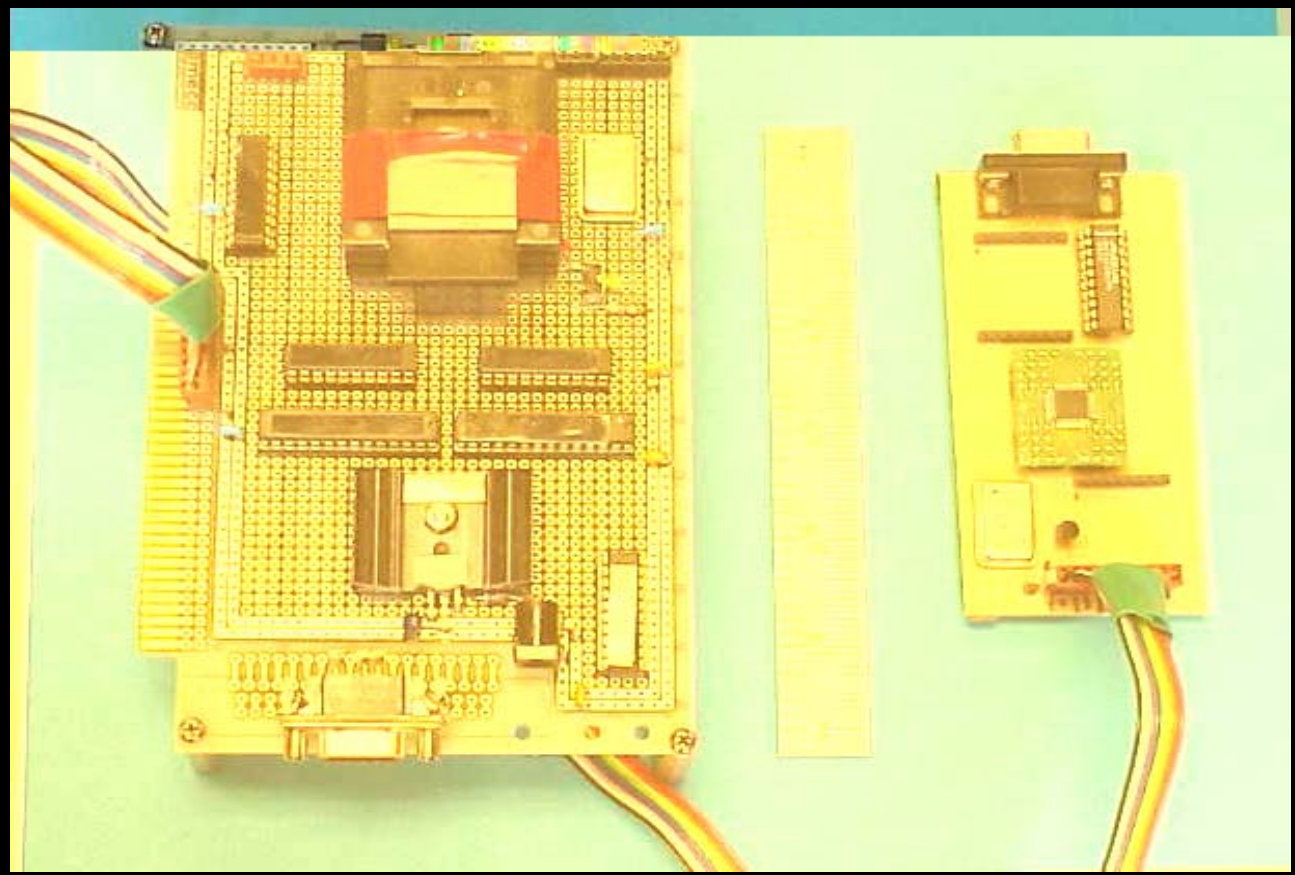
Networked Microcontroller Systems developed at USNA and NIST

- System WAZ_1:
  - Consists of
    - Microchip's high-end microcontroller
    - Seiko's TCP/IP stack S7600
    - External modem
  - External memory required
  - "Monitor" facilitates program development and debugging
- System WAZ_2:
  - Consists of
    - Microchip's mid-range microcontroller
    - Seiko's TCP/IP stack S7600
    - built-in modem
  - Interactive software
  - Microcontroller programmed in-circuit

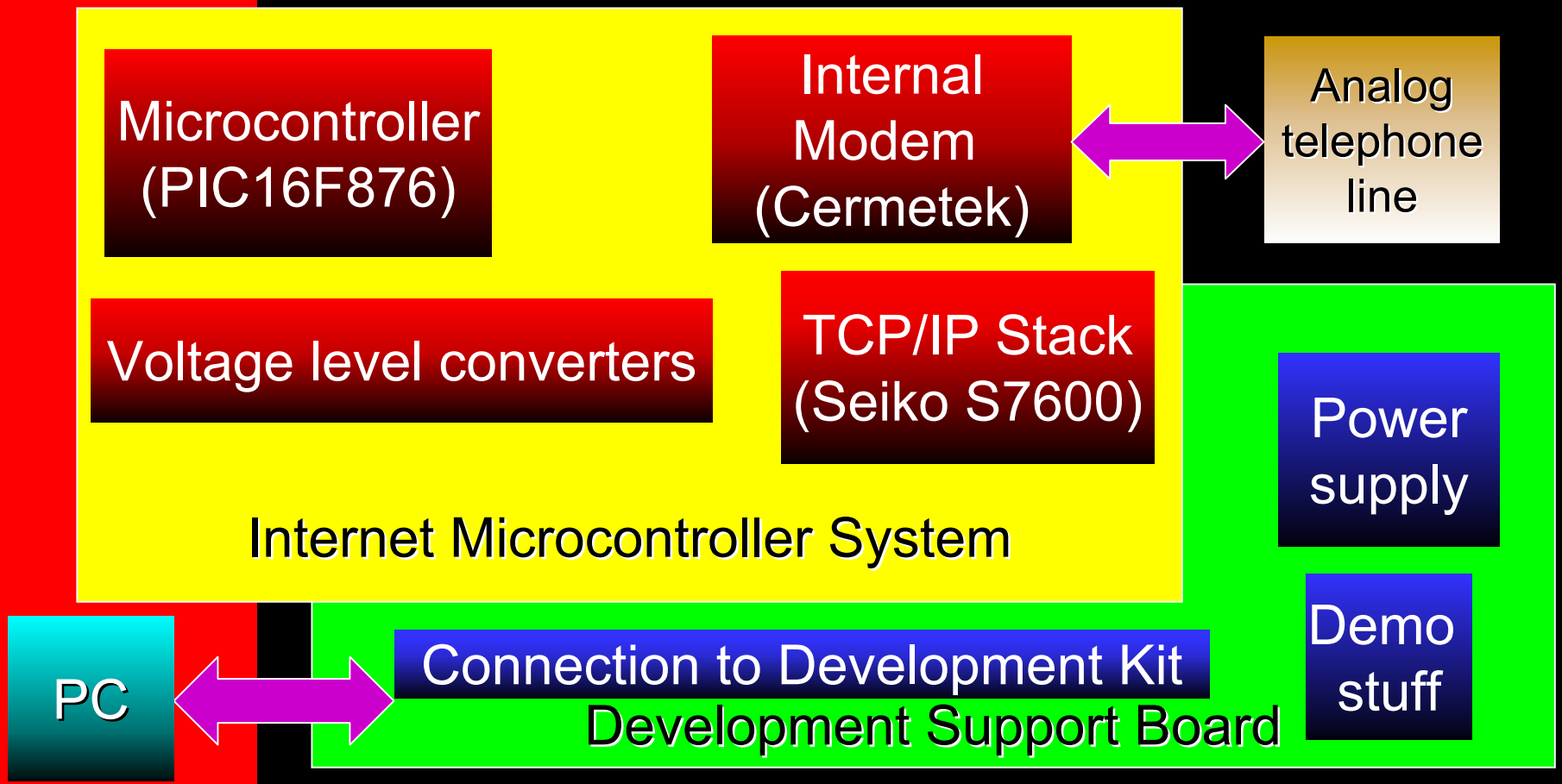
WAZ_1 System


TCP/IP Stack (Seiko S7600)
Voltage level converters
Network module
Microcontroller (PIC 17C756)
Power supply
Memory
Microprocessor
Analog telephone line
External Modem (Boca)
PC used for software development

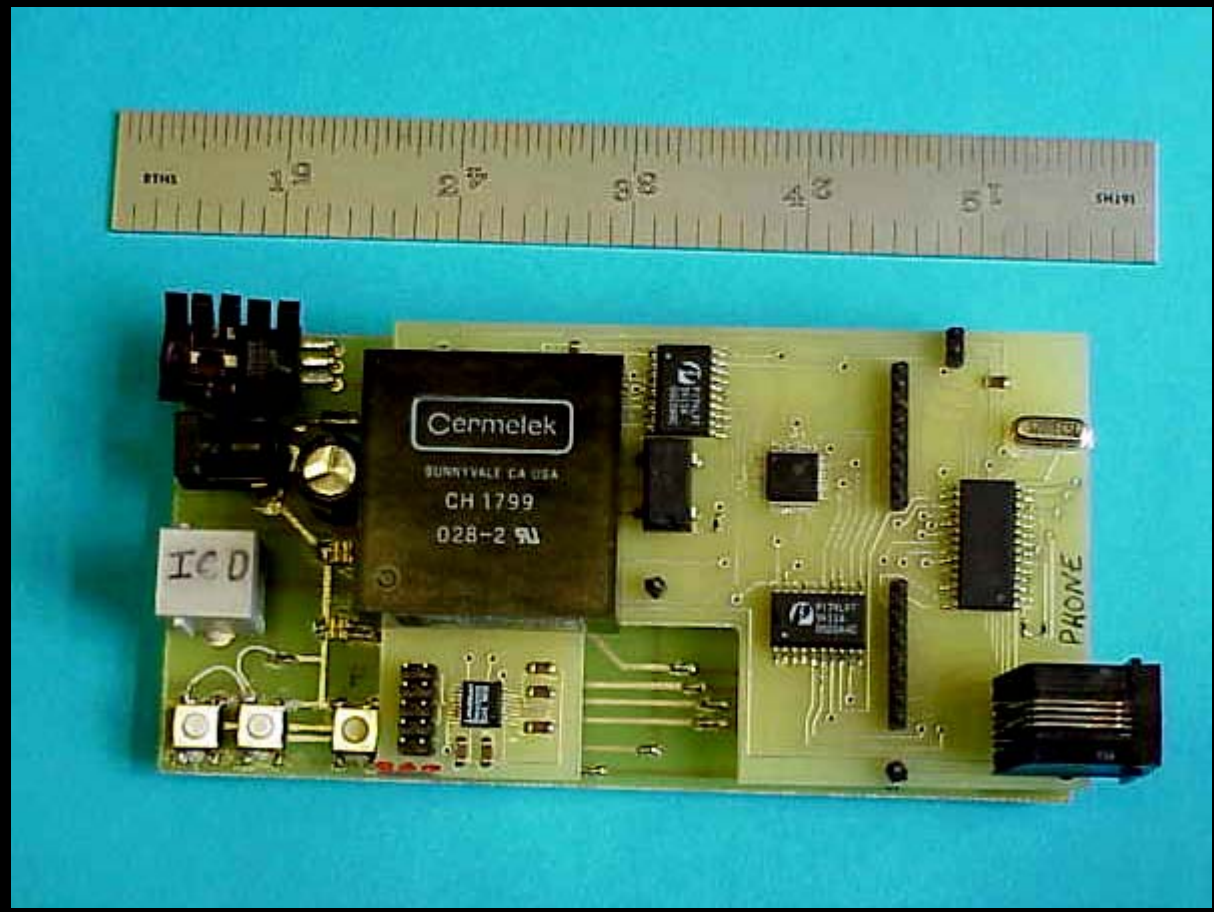
WAZ_1 System



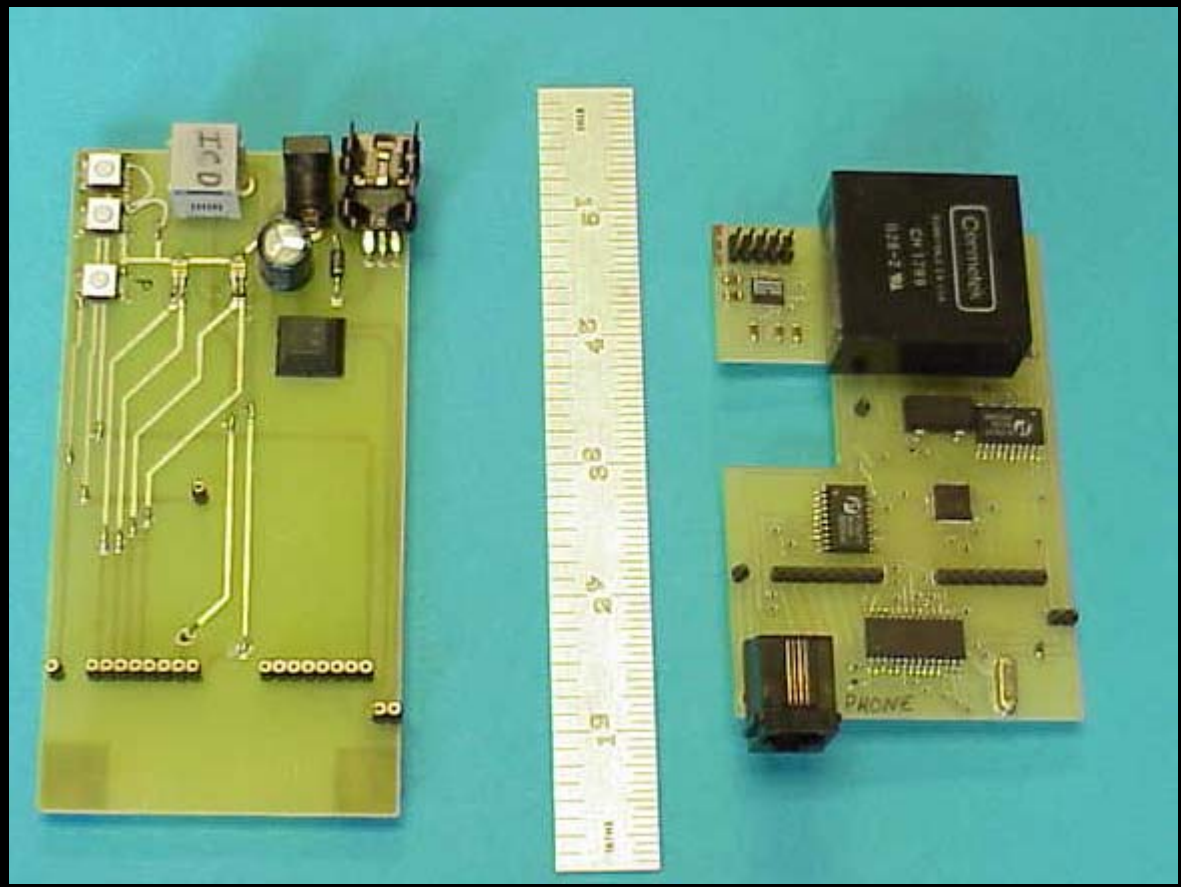
WAZ_2 System


Microcontroller (PIC16F876)
Internal Modem (Cermetek)
Analog telephone line
Voltage level converters
TCP/IP Stack (Seiko S7600)
Power supply
Internet Microcontroller System
Demo stuff
PC
Connection to Development Kit
Development Support Board

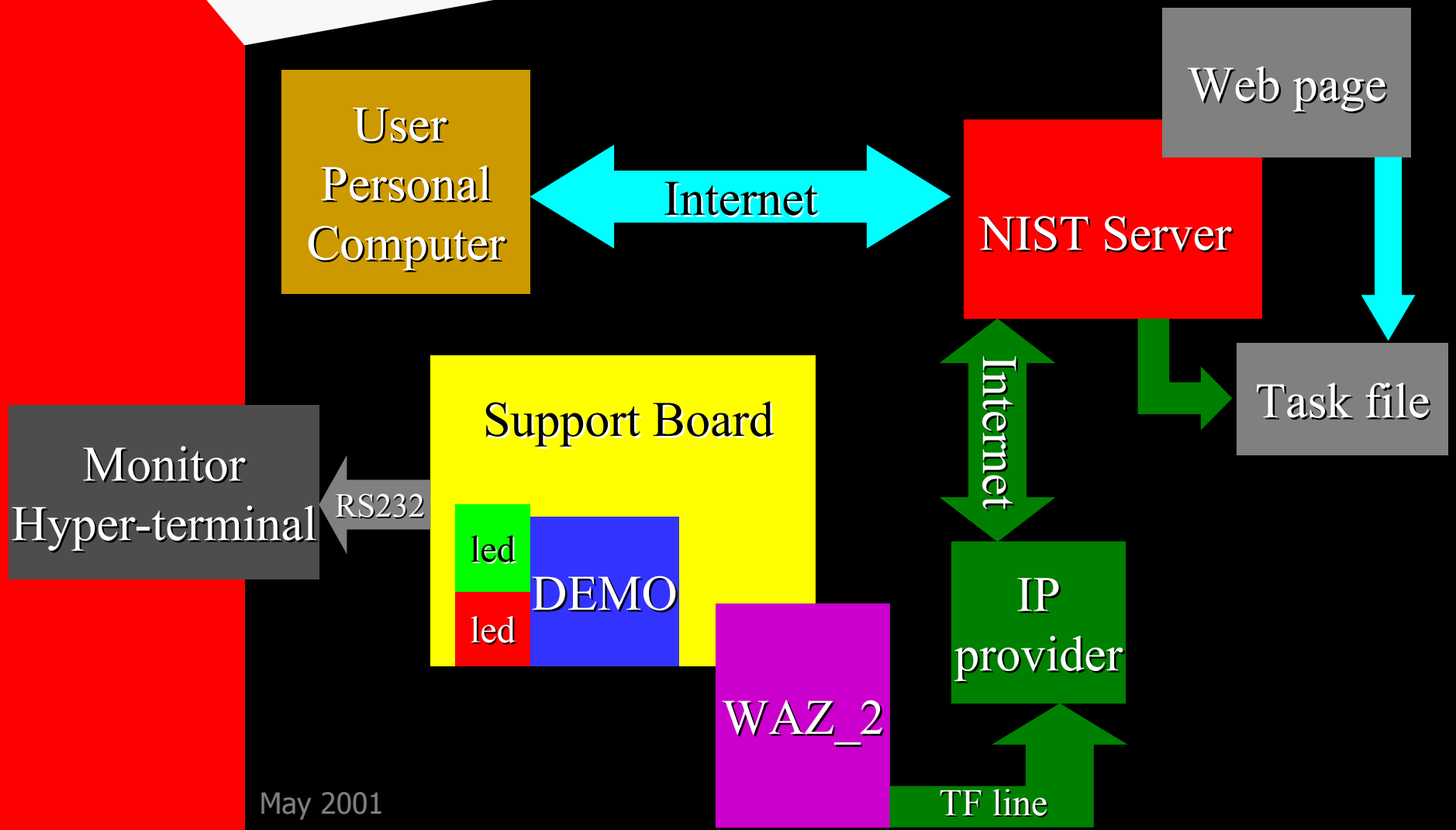
WAZ_2 System



WAZ_2 Development and Deployment Modules



Demo: Architecture



Establishing a connection

- Microprocessor controls modem
  - modem initialization
  - connect command
    - Internet provider's phone number stored in memory
    - log in and password stored in memory
- TCP/IP stack controls connection
  - PPP connection established
  - IP address received

Establishing TCP connection

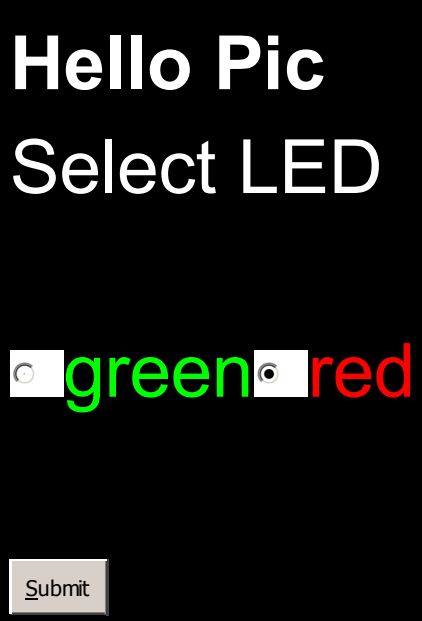
```
        write_reg THR_IP0,21        ;target IP adress
        write_reg THR_IP1,20
        write_reg THR_IP2,6
        write_reg THR_IP3,129
        write_reg H'20',0           ;socket index
        write_reg H'22',H'10'       ;socket configuration status low
        movlw     H'81'             ;wait after reset
        call WAIT
        write_reg H'36',80          ;target port info
        write_reg H'37',0
        write_reg H'38',1           ;our port info
        write_reg H'39',0
        write_reg H'22',2           ;tcp client mode
        write_reg H'24',1           ;socket 0 activate
        movlw     H'88'                       ;
        call WAIT
        movlb 1
        movlw H'10'
        movwf VAL
loopm8  putlit 's'
        read_reg H'23'              ;socket status pooling untill connection is established
        puthex regdata
        andwf regdata,WREG
        btfsc ALUSTA,Z
        goto loopm8
```

Demo: Functionality

- For the demonstration we have a web page where a user submits a request to light a red or a green LED.
- This request is stored in a ‘task file’.
- Microcontroller downloads this ASCII file and performs the task
- The connection is terminated after the task has been completed

Demo Site:

http://xsun.sdct.itl.nist.gov/~avramov/hellopicframes.htm



Demo:
Downloading task file

- Provide IP address and port of server where the task file is stored
- Provide the method by which the task file will be obtained and its exact location on the target server
  - in our example we used GET method to obtain text file stored on a server at NIST
  - task page location is: http://xsun.sdct.itl.nist.gov/~avramov/old_query.txt

Demo: Network Session
(monitored using hyper terminal)

- SEIKO READY
- MODEM READY
- c ;make connection
- DIALING 918005004767
- CONNECT TO SERVICE
- OUR IP: 81061F0A
- THEIR IP: 81061415
- GET ;get task file
  http://xsun.sdct.itl.nist.gov/~avramov/old_query.txt
- LED=red

Examples:
Loading and recovering connection information

- Recover phone number => rf 18005004767
- Load IP address of a server where task file is located => li12962021
- Password =>p
- Login =>l
- Method =>M

WAZ_2 Budget

Component	COST 1000 units	COST 1 unit
Microcontroller	$ 5	$ 10
TCP/IP Stack	$ 8	$ 10
Level shifters	$ 2	$ 5
Modem	$ 55	$ 100
RS232	$ 2	$ 5
Circuit board	$ 2	$ 20
Support components	$ 1	$ 5
TOTAL	$ 75	$ 155

Conclusions

- The demo shows that the overall data flow required for networked applications can be realized using microcontroller technology
- All of the Internet protocols and procedures were implemented
- Existing hardware provides low-cost solutions for microcontroller Internet connectivity

Conclusions

- Very robust Internet-connected microcontroller systems can be built
- Pervasive computing developers should not overlook 8-bit microcontroller-based solutions

Contact information

- Svetlana Avramov-Zamurovic
  - avramov@usna.edu
- Carl Wick
  - wick@usna.edu

  - Weapons and Systems Engineering Department
  - United States Naval Academy
  - 105 Maryland Avenue
  - Annapolis MD 21402